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Superseding AMS5586F

Nickel Alloy, Corrosion and Heat-Resistant, Welded Tubing
57Ni - 19.5Cr - 13.5Co - 4.2Mo - 2.9Ti - 1.4Al - 0.006B - 0.08Zr
Consumable Electrode Remelted or Vacuum Induction Melted, Annealed
(Composition similar to UNS N07001)

RATIONALE

AMS5586G has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

1.1 Form

This specification covers a corrosion and heat-resistant nickel alloy in the form of welded and drawn tubing.

1.2 Application

This tubing has been used typically for parts requiring high strength up to 1500 °F (816 °C) and oxidation resistance up to 1750 °F (954 °C), but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), or www.sae.org.

AMS 2263	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Tubing
AMS 2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys
AMS 2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2634	Ultrasonic Inspection, Thin Wall Metal Tubing
AMS 2807	Identification, Carbon and Low-Alloy Steels, Corrosion and Heat-Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing

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2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, or www.astm.org.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 112	Determining Average Grain Size
ASTM E 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
ASTM E 426	Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys
ASTM E 1417	Liquid Penetrant Examination

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - COMPOSITION

Element	min	max
Carbon	0.02	0.10
Manganese	--	0.10
Silicon	--	0.15
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	18.00	21.00
Cobalt	12.00	15.00
Molybdenum	3.50	5.00
Titanium	2.50	3.25
Aluminum	1.20	1.60
Boron (3.1.1)	0.003	0.010
Zirconium	0.02	0.15
Iron	--	2.00
Copper	--	0.10
Nickel	remainder	

3.1.1 Boron may be less than 0.003% by weight, determined on tubing having nominal wall thickness under 0.050 inch (1.27 mm), provided the specified requirement is met on the stock from which sheet or strip for making tubing is rolled.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS 2269.

3.2 Melting Practice

Alloy shall be produced by multiple melting using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used for remelting.

3.3 Condition

Annealed, and unless annealing is performed in an atmosphere yielding a bright finish, pickled as required. Cooling from the annealing temperature shall be at a rate equivalent to an air cool or faster. Tubing 2.00 inches (50.8 mm) and under shall have been cold worked sufficiently to ensure proper weld reinforcement height and roundness in the weld reinforcement area.

3.4 Fabrication

Tubing 2.00 inches (50.8 mm) and under in nominal OD shall be produced by a welded and drawn process. Any surface finishing operation applied to remove objectionable pits and surface blemishes shall be performed prior to final solution heat treatment. A light polish to improve external surface appearance may be employed after annealing.

3.5 Properties

Tubing 0.125 inch (3.18 mm) and over in nominal OD and 0.015 inch (0.38 mm) and over in nominal wall thickness shall conform to the following requirements:

3.5.1 As Annealed

3.5.1.1 Tensile Properties

Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2 - TENSILE PROPERTIES

Property	Value
Tensile Strength, max	145 ksi (1000 MPa)
Yield Strength at 0.2% Offset, max	80 ksi (552 MPa)
Elongation in 2 Inches (50.8 mm) or 4D, min	35%

3.5.1.2 Flarability

Specimens as in 4.3.1 shall withstand flaring at room temperature, without formation of cracks or other visible defects, by being forced axially with steady pressure over a hardened and polished tapered steel pin having a 74-degree included angle to produce a flare having a permanent expanded OD not less than 1.2 times the nominal OD.

3.5.1.3 Average Grain Size

Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112.

3.5.2 After Solution, Stabilization, and Precipitation Heat Treatment

Tubing shall meet the requirements of 3.5.2.1, 3.5.2.2, and 3.5.2.3 after being solution heat treated by heating in a suitable atmosphere to 1825 °F ± 25 (996 °C ± 14), holding at heat for 2 hours ± 0.25, and cooling at a rate equivalent to an air cool or faster; stabilization treated by heating to 1550 °F ± 15 (843 °C ± 8), holding at heat for 4 hours ± 0.25, and cooling at a rate equivalent to air cooling; and precipitation treated by heating to 1400 °F ± 15 (760 °C ± 8), holding at heat for 16 hours ± 1, and cooling at a rate equivalent to air cooling.

3.5.2.1 Tensile Properties

Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 3 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	160 ksi (1103 MPa)
Yield Strength at 0.2% Offset	105 ksi (724 MPa)
Elongation in 2 Inches (50.8 mm) or 4D	15%

3.5.2.2 Hardness

Shall be 34 to 44 HRC, or equivalent (See 8.2), determined in accordance with ASTM E 18.

3.5.2.3 Stress-Rupture Properties

Shall be as follows, determined in accordance with ASTM E 139; the test at 1500 °F (816 °C) (3.5.2.3.2) need be run only if the tubing fails to pass the test at 1350 °F (732 °C). Tubing which passes the test of 3.5.2.3.2 will be acceptable.

3.5.2.3.1 At 1350 °F (732 °C)

A tensile specimen, maintained at 1350 °F $\pm$ 3 (732 °C $\pm$ 2) while a load sufficient to produce the initial axial stress shown in Table 4 is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not less than shown in Table 4.

TABLE 4A - STRESS RUPTURE REQUIREMENTS, INCH/POUND UNITS

Nominal Wall Thickness Inch	Stress ksi	Elongation in 2 Inches or 4D %, min
0.015 to 0.020, incl	62.5	4
Over 0.020 to 0.030, incl	65.0	4
Over 0.030 to 0.050, incl	67.5	4
Over 0.050	70.0	5

TABLE 4B - STRESS RUPTURE REQUIREMENTS, SI UNITS

Nominal Wall Thickness Millimeters	Stress MPa	Elongation in 50.8 mm or 4D %, min
0.38 to 0.51, incl	431	4
Over 0.51 to 0.76, incl	448	4
Over 0.76 to 1.27, incl	465	4
Over 1.27	483	5

3.5.2.3.2 At 1500 °F (816 °C)

A tensile specimen, maintained at 1500 °F $\pm$ 3 (816 °C $\pm$ 2) while a load sufficient to produce an initial axial stress of 37.5 ksi (259 MPa) or higher is applied continuously, shall not rupture in less than 23 hours. Elongation after rupture, measured at room temperature, shall be not less than 5% in 2 inches (50.8 mm).

3.5.2.3.2.1 The test of 3.5.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 37.5 ksi (259 MPa) or higher shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 hours, minimum, the stress shall be increased in increments of 2.5 ksi (17 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.2.3.2.

3.6 Quality

Tubing, as received by purchaser, shall be uniform in quality and condition and shall have a finish conforming to the best practice for high quality aircraft tubing. It shall be smooth and free from grease, oil and other matter, heavy scale or oxide, burrs, seams, tears, grooves, laminations, slivers, pits, and other imperfections detrimental to usage of the tubing. Surface imperfections, such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale pattern, will not be considered injurious if the imperfections are removable within the tolerances specified for wall thickness, but removal of such imperfections is not required.

3.6.1 If weld reinforcement is present at the weld on the inner surface of tubing over 2.00 inches (50.8 mm) in nominal OD, such weld reinforcement shall be not thicker than 0.010 inch (0.25 mm). The outer surface of all tubing and the inner surface of tubing 2.00 inches (50.8 mm) and under in nominal OD shall be free from weld reinforcement.